A MORPHOLOGICAL STUDY OF SELECTED THICK-SURFACED SOUTHERN BRUNIZEMIC SOILS

By

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CHAPTER I

INTRODUCTION

Soils similar to the thick-surfaced Brunizemic Planosols studied by Brengle (7) occur extensively in the humid, grassland area of eastern Oklahoma and adjacent states. These soils are presently being classified as either Taloka or Choteau soil series. Both soils have developed under the influence of grass but possess thick, highly leached A2 horizons. Present concepts include a less abrupt A2 to B2t boundary for the Choteau series and a somewhat more clayey and firmer B2t horizon for the Taloka series.

In the process of mapping the Eastern Oklahoma Pasture Research Station, located south of Muskogee, many profiles were observed that were similar to the Taloka and many were observed that had similar horizonation but with less clay accumulation in the B horizon. These differences necessitated different soil types or mapping units. Adjacent counties and areas also possess similar soil types and soil associations. From a careful observation of the local landscapes, less clayey soils with similar profile horizonation occur on two distinctly different land forms. An area of similar pedons occupies gentle convex footslopes, whereas another area of similar pedons is found on the weakly convex upland flats. In each land form, the associated soils are fine textured and closely resemble the Taloka soils studied by Brengle (7), and those later mapped and classified in the Okmulgee

County Soil Survey (51). The less clayey pedons were described and sampled to represent each land form and tentatively have been labeled Choteau-L (like) and Choteau-V (variant) for study purposes.

More precise morphological information is needed to determine whether the soils of the two different land forms are similar and of the same soil series. To do this, physical, chemical, and mineralogical determinations need to be made on the important features of each profile to explain their similarities or differences. These data will be helpful in determining the kinds of soil forming processes that occurred during soil development. The data will also permit comparisons with other Choteau soils and with those obtained by Brengle on the Taloka soils.

After placing the soils in series, attempts will be made to objectively classify the pedons by the definitions now found in the 7th Approximation.

All the information obtained in this study will be helpful in interpreting the soils behavior for agricultural and non-agricultural uses of similar soils.

CHAPTER II

LITERATURE REVIEW

The soils of this study do resemble the Choteau soil which was first recognized and established as a soil series in Wagoner County in 1942 (55).[1] In the early survey of Muskogee County (29), they were mapped and classified as Gerald silt loam. In later surveys (32, 33) some were mapped as Parsons silt loam, deep phase. Until recently, Taloka and Choteau were included in the same soil series, but are now recognized as different soils in a natural soil association. Today Choteau silt loam is mapped in many counties of eastern Oklahoma.

Geography of the Study Area

The study area is located in the southcentral part of Muskogee County which is located in the eastern part of Oklahoma and embraces an area of 814 square miles. The elevation varies between 550 feet in the Arkansas river bed to 950 feet on the steeper uplands and hills. Locally there is not more than 150 feet of relief from the valley to the hill tops (29).

Geology and Land Forms

Rocks that out crop in the Muskogee area and underlay the soils of the study area are of early and middle Pennsylvanian age and are

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[1]Numbers in parentheses refer to literature cited.

members of the Boggy unit of the Krebs group. The members of this group are mostly sandstone, siltstone and shale. The sandstone ranges from soft to hard, tan to gray in color and in beds with thicknesses of a few inches up to 40 feet. The shales contain lenses of sandstone and siltstone (2, 37).

Bell (2) has reported the Boggy unit to be a mass of shale and sandstone. He identified not less than 16 beds of sandstone (20-150 feet thick) separated by 100-600 feet of shale. The shales are bluish and grayish brown, locally very silty and micaceous, and contain ironstone concretions. The sandstones are uniformly textured, brownish or gray in color, mostly silty to fine grained sand that is highly cemented with iron oxides and are micaceous. to here

The Atoka unit has been studied by Rutledge, Horn, and others (43, 58). They reported that zircon and tourmaline accounted for over 90% of the heavy minerals; with rutile, brookite and muscovite making up 8.3%. They also found that the light minerals in the very fine sand of soils developed from these rocks were entirely quartz with no identifiable feldspars.

The land forms consist of broad, flat, shale valleys and hills and ridges capped with sandstones and siltstones. See Figure 1.

Climate

The area is in a warm summer, humid, continental climate. The rainfall is rather uniform throughout the year. The summers are usually the driest and the late winter and early springs are the wettest. The average annual rainfall is between 38-42 inches. The mean annual temperature is 62°F (16.7°C). The average summer temperature is

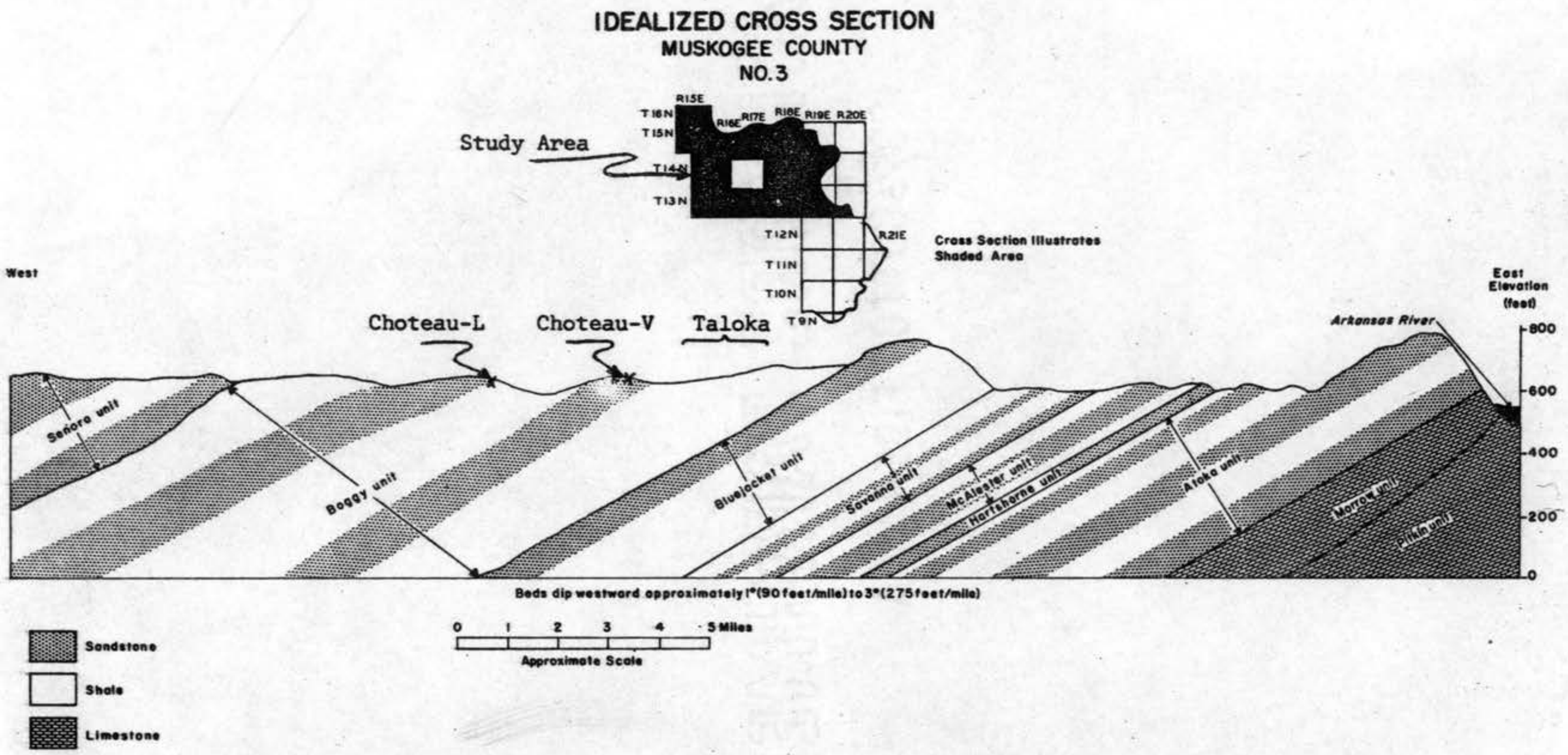

Figure 1. Idealized Cross Section Showing the Geology and Soil Position of the Sample Area

80°F (26.7°C) with maximums of 105° + F. The average winter temperature is 42°F (5.6°C) with minimums of -5°F (9, 29). The P.E. index of the area ranges from 70-72 (54).

Vegetation

The native vegetation of the area consists mainly of tall and mid grasses. Some trees occur mainly on the steeper, sandy ridgetops and slopes and occasionally along stream bottoms. Because of the very prominent A2 horizons present in the soil profiles, the area may once have been covered by a deciduous forest.

Gleason (14) has suggested that the expansion of the forests was stopped and the areas diminished mainly as a result of prairie fires usually associated with the American Indians. Curtis (10) has cited numerous accounts of early observers of forested areas that were completely destroyed, and the areas then becoming occupied by prairie vegetation. This exact occurrence may account for a part of the Cherokee Prairie.

Coatings of light gray silt and sand are commonly found on peds of B-horizons in well drained Udolls of eastern Iowa (50, 53). The presence of these coatings is not considered typical of Udolls, and it is believed that these coatings form more commonly under deciduous forest rather than under prairie vegetation (1). Similar coatings are common in the Choteau soils and add to the idea of a past forest area.

Soil Development of Similar and Associated Soils

The processes of soil formation and the development of very prominent horizons is very apparent in the Planosols. Bray (4) has investigated the processes by which differentiation of textural horizons takes place in soils of level prairie regions. He found that it was essentially the formation of a 2:1 lattice clay in the A and B horizons, with removal of part of the clay in the A and the translocation by percolating waters into the B horizons. Numerous studies (3, 5) on the Putnam series, a Prairie Planosol, have indicated that indeed the clays were essentially a mixture of illite and beidellite, with the finer clays mostly beidellite. The soil was developed from uniform loess and the heavy subsoil was the result of formation of clay by weathering of primary minerals, and the translocation downward of clay plus the clay in the parent material. Tobler

The Grundy series, another Planosol, was examined by Marshall and Haseman (34). They were found to be similar to the Putnam in development of clays and factors of soil formation. Numerous workers have reported an interesting relationship about these loess-derived soils. They have all found that there is an increase in clay content in the Bt horizons with decreasing loess thickness (22, 49, 52).

Ruhe's work in Iowa (42) has disclosed several distinct age groups of soils. He found gray-brown Podzolic soils associated with Brunizems on similar slopes and surfaces. He suggests that the prairie environment has masked the effects of other environments. He has also indicated that distinguishing Paleosols by use of hydrogen ion concentrations has proved difficult and misleading (41). The A2 of a Paleosol had pH's of 6.4 and the B2's 6.6. Simonson (46) reported similar values in paleo-Planosols. Yet Ulrich (53) found that less extensively weathered modern Planosols in Iowa have pH values in the A2 of 5.0 and the B2 of 5.6. Ruhe suggests a detailed mineralogical study and the establishing of a weathering ratio can best be applied to Paleosol recognization.

Jarvis and Bidwell (28) have worked on the Taloka soils in Kansas. They stated that the soil was developed from non-calcareous shale and from pre-Pleistocene sediments. The clays were dominantly montmorillonite with smaller amounts of illite and kaolinite. There were no differences in the proportions of clay minerals other than amounts in the A and B horizons and they could find no decisive evidence to indicate a loess mantle. They believed the soil was a one solum soil. They did not make any attempt to account for the thick A2 horizons.

Brengle and Gray (7) concluded that the Taloka soil in Oklahoma has more than one solum and has characteristics of Paleosols. They found marked fluctuations in pH, exchangeable hydrogen and an increase in organic matter in the B21t horizons. There was also a noticeable variation in particle size distribution and heavy mineral contents. They attributed these differences to a partially developed buried soil and to depositional changes in the loess respectively. They found montmorillonite to be the dominant clay mineral.

Rutledge and Horn (43) worked in Arkansas on extremely silty soils believed to have developed all, or in part, from loess. They concluded, however, that the soils were developed in residuum. In later research, Chapman and Horn (8) used TiO_2 and ZrO_2 ratios to study uniformity of parent materials of fifteen soils having silty surfaces. The soils were developed from several different parent materials, and in all but one case, their ratios with depth were uniform. They concluded that these soils developed in locally derived materials and did not have loess overburdens. They postulated that the source of the relatively large quantities of silt resulted from the release of silt-sized quartz grains from chert and from siltstone, silty sandstone and other sedimentary rocks of the Boone, Atoka, and other geologic formations.

Feldspars, an Index to Weathering

Marshall (34) has stated that certain minerals which slowly decompose under humid weathering conditions provide a quantitative clue to soil maturity. The identification and chemical composition of heavy and light minerals in soils are of great importance when studying soil weathering processes.

Because of the increased emphasis placed on soil age and soil weathering, Graham, Marshall (16, 35) worked out soil weathering indices. Hawkins (20) established an index of relative weathering, and was able to show that albite weathered far slower than the other feldspars and that anorthite was the least resistant to weathering. He also proposed a calcium-sodium ratio could represent the state of soil maturity, if calcium was present in the parent material. Since feldspars weather more readily than quartz, Kiely and Jackson (30), have proposed a quartz-feldspar ratio as an index to weathering.

Quartz and feldspars are present in nearly all fractions of many soils. The amounts and kinds vary from soil to soil. Graham (15) has found from 0.5% to 0.7% Ca, and 1.0% to 1.8% Na and K feldspars in Missouri soils. Matelski (36) has found from 10% to 25% K-feldspars in the Sandhill soils of Nebraska. Kiely and Jackson (30) have found from 2% to 4% K, 1% to 4.5% Na and no Ca feldspars in the fine sand, very fine sand and coarse silt in the Moorepark soils.

CHAPTER III

LABORATORY METHODS AND PROCEDURES

Bulk samples were collected from each horizon, dried and screened. Sub-samples were taken from the bulk samples for analyses. All determinations made on samples were run in either duplicate or triplicate, and average values are reported in the tables.

Physical Analyses

A fifty gram soil sample was prepared and particle-size distribution determined on the sample by the pipette method described by Kilmer and Alexander (31), except the soil was dispersed in boiling sodium carbonate rather than using sodium hexametaphosphate. The remaining silt and clay from the mechanical analysis were redispersed, the silt was allowed to settle out and the clay was decanted. The process was repeated until all the clay was removed. The clay from selected horizons was then separated into fine clay (0.2μ) and coarse clay (2μ-0.2μ) fractions using a continuous flow refrigerated Servall Superspeed Centrifuge.

Bulk density of the horizons was determined by the coated-clod method described by Westin (56).

Chemical Analyses

The pH of the soil horizons was determined from a 1:1 soil-water paste and from a soil-1N KCl mixture (24) using a Beckman pH meter.

Organic matter was determined by the potassium dichromate wet oxidation method of Scholenberger (44) with modifications by Harper (18). Soil cation exchange capacity was determined by saturation with ammonium acetate and then determining the exchangeable ammonium by Kjeldahl distillation (26). The CEC-ammonium acetate leachate was saved to determine extractable cations. The sodium and potassium were determined with a Beckman DU Spectrophotometer and calcium and magnesium were determined by titration with Versenate (40). Extractable hydrogen was determined by the barium chloride-triethonalamine method of Peech (39). Base saturation was calculated and reported by two different methods: (a) the sum of the total extractable metallic cations divided by the Kjeldahl CEC = base saturation, (b) the sum of the total extractable metallic cations + hydrogen = CEC and the CEC divided into the extractable cations = base saturation. Total phosphorus determinations were made by digestion of the soil in perchloric acid and phosphorus was determined by development of a molybdate complex color method outlined by Shelton and Harper (45). Available phosphorus was determined by the method of Bray and Kurtz (6).

Free iron in the soil was removed by the sodium citrate-sodium bicarbonate buffer method (23) and the extract used to determine the amount of iron. The determination was made colormetrically by the Tiron method (25). The combining of both procedures necessitated the removal of the citrates because of their interference with the color development. This was accomplished by drying and digesting an aliquot of the extract twice with 3:1 conc. nitric-perchloric acid and one additional time with conc. nitric acid. Titanium was also determined on the same sample after destroying the iron complex (25). Total manganese was extracted from the soil by an HCl digestion described by Harper (19), and determined by the sodium periodate color method of Hunter and Coleman (21).

Clay Mineralogical Analyses

The cation exchange capacities of the clays were determined on the total, coarse and fine fractions by saturation with sodium acetate (26) and removing the exchanged sodium and determining it on the spectrophotometer. Total potassium of the clays was determined by digestion in HF and the potassium determined on the spectrophotometer. The quartz and feldspars were determined by a wet chemical method outlined by Kiely and Jackson (30). The determination of a calcium required the removal of aluminum from the dissolved feldspar solution by the ammonium hydroxide separation (27) and was then determined by Versenate (40). Sodium and potassium were determined on the spectrophotometer.

CHAPTER IV

DESCRIPTIONS OF THE SAMPLED SOIL PEDONS

Two pedons that resemble the Choteau series were sampled and described from pits on the Oklahoma State University Eastern Pasture Station. One soil, Choteau-L, was sampled on a gently sloping area associated with Collinsville and Bates soils on steeper slopes. Choteau-V was sampled on an upland flat. See Figure 1.

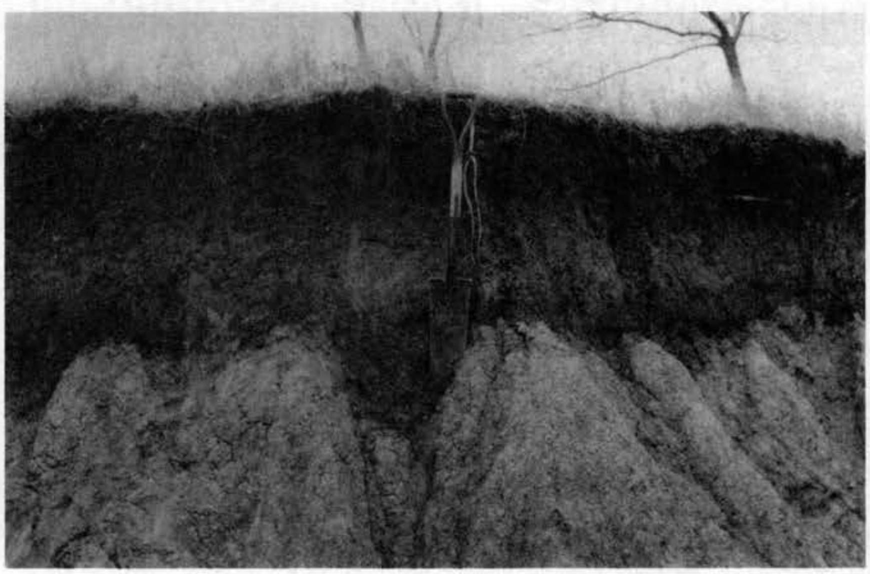

Figure 2. Roadside Cut Showing Exposed Profile of Choteau Series

Choteau silt loam - L

Location: Southeast of Muskogee on the Oklahoma State University Eastern Pasture station. 685 feet north and 280 feet east of the southeast corner of SE 1/4, of Section 32, T14N; R17E.

Native Vegetation: Tall grass prairie, but near the forest-grass tension zone. Prairie consisted of Big Bluestem (*Andropogon gerardi*), Little Bluestem (*A. scoparius*), Switchgrass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*). Land is now in cultivation.

Parent material: Weathered siltstone or silty shales.

Topography: Smooth 2-2.5% north facing footslope joining soils on steeper slopes.

Soil Profile:

AP	0-10"	Dark grayish brown (10YR 3.0/2 moist) silt loam, grayish brown (10YR 5/2); weak fine granular; friable; permeable; numerous roots and worm casts; pH 5.6; grades to horizon below.
A21	10-18"	Dark grayish brown (10YR 4/2 moist) silt loam, grayish brown (10YR 5/2); porous massive; very friable and hard; permeable; numerous roots and many worm casts; few faint stains of dark yellowish brown (10YR 4/4); pH 5.0; clear boundary.
A22cn	18-24"	Brown (10YR 5/3 moist) silt loam, light brownish gray (10YR 6/2); very porous massive; very friable and very hard; clear distinct stains or mottles of dark yellowish brown (10YR 4/4), much of the color due to fine and medium ferruginous concretions; small pockets of soil material from the AP; many worm casts; pH 5.0; clear boundary.
B1	24-30"	Brown (10YR 5/3 moist) heavy silt loam, pale brown (10YR 6/3); very weak, medium blocky to somewhat porous massive; friable and hard; common fine and medium mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4), much of the color due to staining by concretions; many black and brown iron-manganese concretions up to 1/2" in diameter; pH 5.5; abrupt wavy boundary.

B21t	30-38"	Mottled light gray (10YR 7/2 moist), gray (10YR 5/1 moist), light yellowish brown (10YR 6/4 moist) and yellowish brown (10YR 5/6 moist) silty clay loam; weak course blocky to massive; firm and hard; cleavage planes break easily but are very weak; thin continuous clay skins on both horizontal and vertical faces; some concretions; many pipestems and channels of pale brown very fine sand and silt are found throughout the horizon; pH 6.6; grades to horizon below.
B22t	38-53"	Mottled colors as above, but mottles are coarser; silty clay; weak coarse blocky to massive, very firm and very hard; very few cleavage planes, but thick distinct clay skins are continuous on all peds; few concretions; pipestems of pale brown very fine sand and silt very pronounced but end in lower portion of horizon; pH 7.3; diffuse wavy boundary.
B23t	53-64"	Mottled colors as above, but not as coarse; silty clay loam; massive; slightly firm and hard; common weak patchy clay skins; few concretions, pH 7.2; diffuse boundary.
B31	64-80"	Strongly mottled brownish yellow (10YR 6/8), yellowish brown (10YR 5/8) and very pale brown (10YR 7/3) clay loam; massive; firm and hard; much of the horizon is made up of black and brown ferro-manganese material that is soft when moist; it appears as large patches in the soil mass and also coats parts of other soil material; pH 7.4; gradual boundary.
C	80-90"+	Strongly mottled yellow (10YR 7/8), brownish yellow (10YR 6/8), dark brown (10YR 4/3), black (10YR 2/1) and very pale brown (10YR 7/3) more and brighter yellows than horizon above, clay loam; massive; firm and slightly hard; much ferro-manganese material, like above; pH 7.4. Probably weathered soft silty shales or siltstones.

Choteau silt loam - V

Location: Southeast of Muskogee on Oklahoma State University Eastern Pasture station. 550 feet north and 790 feet west of the southeast corner of the SE 1/4, of Section 29, T14N; R17E.

Native Vegetation: Tall grass prairie, but near the grass-forest tension zone. Prairie consisted of Big Bluestem (Andropogon gerardi), Little Bluestem (A. scoparius), Switchgrass (Panicum virgatum), and Indian grass (Sorghastrum nutans). Land is now in cultivation.

Parent Material: Weathered siltstone.

Topography: Broad convex ridge that is nearly level with slopes from 0.5 to 1%. There is no land higher above this area for 1/2 to 1 mile in any direction.

Soil Profile:

A1	0-14"	Dark grayish brown (10YR 4/2 moist) silt loam, brown (10YR 5/3); weak fine granular, friable; permeable; numerous roots and worm casts; pH 5.0; grades to horizon below.
A21	14-20"	Dark brown (10YR 4/3 moist) silt loam, pale brown (10YR 6/3), weak fine granular to porous massive; friable and slightly hard; permeable; few fine faint mottles or stains of dark yellowish brown (10YR 4/4 moist), mostly staining from the common fine black and brown concretions; many worm casts; pH 5.1; grades to horizon below.
A22	20-26"	Yellowish brown (10YR 5/4 moist) silt loam, light yellowish brown (10YR 6/4); very porous massive; very friable and hard; common prominent fine and medium mottles of brown (10YR 5/3 moist) and dark yellowish brown (10YR 4/4 moist) that are mainly staining from the many fine and medium concretions; many worm casts and root channels; pH 5.3; abrupt wavy boundary.
B21t	26-30"	Mottled dark yellowish brown (10YR 4/4 moist) grayish brown (10YR 5/2 moist) and strong brown (7.5YR 5/6 moist), heavy silty clay loam, with occasional mottles of dark reddish brown (5YR 3/4 moist) and red (2.5YR 4/8 moist), weak coarse blocky to massive; very firm and very hard; breaks easily when moist but has weak cleavage planes, blocks weak to weak medium sub-angular when dry; distinct clay skins present mostly on vertical faces; many concretions; pH 5.8; grades to horizon below.

B22t	30-38"	Mottled heavy silty clay loam. Mottled colors are the same as above only coarser; weak coarse blocky to massive that breaks to weak and moderate medium subangular; distinct clay skins are continuous and many of the root channels are well coated with clay; many concretions that are soft when moist; some fine pipestems and coatings of very pale brown (10YR 7/3 moist) very fine sand and silt; pH 6.3; clear boundary.
B3&C	38-60"	Medium to coarse mottling. Mottled colors still the same, but absent of the reddish brown and red colors; clay loam; massive; firm and slightly hard; common prominent clay skins that are discontinuous and patchy; large iron-manganese concretions and other ferruginous material is common; many thin flat fragments of siltstone make up about 15% of the soil material; pH 7.4; gradual wavy boundary.
R	60-65"+	Thin bedded dark yellowish brown (10YR 4/4) siltstone; pH 8.0.

CHAPTER V

RESULTS AND DISCUSSION

Physical Analyses

Particle-Size Distribution. The particle-size distribution data for the two pedons are presented in Table I. These data point out less clay in the A horizons and accumulations of clay in the B horizons. Clay maxima in the soils are similar, being 39.7% and 41.7% respectively. However, the maxima appear at somewhat different depths. A maximum occurs at the 38-53 inch depth in Choteau-L, and one occurs at the 26-38 inch depth in Choteau-V. Choteau-L shows a decrease to a low of 12% clay in the A22cn horizon and gradually increases to a maximum in the B22t horizon. A small maximum also occurs in the C horizon and is possibly due to the stratified nature of the parent materials. The clay content is the lowest in the surface with 10.9% clay, increases gradually through the A22cn horizon, and then increases abruptly in the B21t and B22t before decreasing again with depth in Choteau-V.

The clay percentages, presences of clay skins, and strongly orientated clay indicated in thin section Figure 10 (Appendix), indicate that clay was translocated in the profile and that clay-sized fractions are more active in soil development than the other particle sizes.

Both are extremely silty soils which possess from 60-66% silt. The amount of silt gradually decreases with depth. Choteau-L contains a larger percentage of fine silt and a smaller percentage of coarse

TABLE I

PARTICLE-SIZE DISTRIBUTION OF THE CHOTEAU SOILS

Horizon	Depth	Very Coarse Sand 2-1 mm	Coarse Sand 1-.5 mm	Medium Sand .5-.25 mm	Fine Sand .25-.1 mm	Very Fine Sand .1-.05 mm	Coarse Silt .05-.02 mm	Fine Silt .02-.002 mm	Clay <.002 mm
	Inches	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
					Choteau-L				
Ap	0-10	0.2	0.2	0.2	4.3	13.4	36.9	28.9	15.9
A21	10-18	0.3	0.4	0.3	4.7	14.5	37.1	28.5	14.2
A22cn	18-24	0.5	0.4	0.2	4.9	15.6	39.5	26.9	12.0
B1cn	24-30	0.7	0.4	0.2	4.8	13.3	31.0	26.4	23.2
B21t	30-38	0.7	0.6	0.3	4.2	10.4	25.2	26.9	31.7
B22t	38-53	0.8	0.5	0.4	3.6	8.4	20.8	25.8	39.7
B23t	53-64	0.7	0.6	0.4	4.8	10.5	22.3	25.9	34.8
B3	64-80	3.3[a]	2.3[a]	1.5	8.1	14.6	21.6	18.7	29.9
C	80-90	1.8[a]	1.5[a]	1.1	7.7	14.6	19.9	16.1	37.3
					Choteau-V				
A1	0-14	5.8	3.3	1.2	1.5	11.2	44.4	21.7	10.9
A21cn	14-20	8.0	3.4	1.1	1.2	8.4	38.4	25.1	14.4
A22cn	20-26	9.7	3.5	1.1	1.4	8.2	33.4	26.3	16.4
B21t	26-30	3.7	1.7	0.7	1.4	5.6	21.8	23.4	41.7
B22t	30-38	3.5	1.7	0.8	1.5	5.9	19.4	26.1	41.1
B3&C	38-60	13.8[a]	4.3[a]	1.6	2.5	5.8	16.1	21.9	34.0
R	60-65	0.0[b]	0.0[b]	6.5	8.9	10.4	23.6	35.3	15.3

[a]Fragments of undispersed rock material and concretions

[b]All rock material ground to pass 0.5 mm sieve

silt, especially in the surface horizons, than Choteau-V. However, Choteau-V shows significantly larger amounts of coarse silt than fine silt in the individual horizons.

Sand contents in both soils range from 13%-29%. The percentage of fine and very fine sand is fairly uniform. These two fractions make up over 90% of the sand fraction in Choteau-L. Greater amounts of the coarser sands and less of the finer sand fractions occur in Choteau-V. Upon microscopic examination, the very coarse, coarse, and much of the medium sand were found to be composed of sesquioxide-cemented concretionary material. However, the sands do not play a very significant role in adding to the soil properties.

Bulk Density

The results of the bulk density determinations are given in Table II. The values range from 1.2 in the A22cn horizon of Choteau-V to 1.6 in the B22t horizon of Choteau-L and the B3&C horizon of Choteau-V respectively. The values generally increase with increasing depth and were highest in the B horizons.

Chemical Analyses of the Whole Soil

Data from the chemical analyses of the Choteau profiles are presented in Tables III and IV.

<u>Hydrogen Ion Concentration</u>. The pH values of the A horizons vary from 5.0 to 5.6 as compared to a range of 6.3 to 7.4 in the B horizons. This is a typical characteristic. In Choteau-L there is a decrease in pH with depth through the A22cn horizon and then gradually increases throughout the rest of the solum. In Choteau-V, there was a gradual

TABLE II

BULK DENSITY OF THE CHOTEAU SOILS

Choteau-L			Choteau-V		
Horizon	Depth in Inches	gms/cc.	Horizon	Depth in Inches	gms/cc.
Ap	0-10	1.3	A1	0-14	1.3
A21	10-18	1.3	A21cn	14-20	1.3
A22cn	18-24	1.3	A22cn	20-26	1.2
B1cn	24-30	1.4	B21t	26-30	1.4
B21t	30-38	1.5	B22t	30-38	1.5
B22t	38-53	1.6	B3&C	38-60	1.6
B23t	53-64	1.5	R	60-65+	1.9
B3	64-80	1.5			
C	80-90+	1.5			

TABLE III

CHEMICAL PROPERTIES OF CHOTEAU-L

Horizon	Depth in Inches	pH 1:1	pH KCl	Organic Matter	Extractable Cations H	Extractable Cations Ca	Extractable Cations Mg	Extractable Cations K	Extractable Cations Na	Cation Exchange Capacity	Base Saturation (a)	Base Saturation (b)	Phosphorus Bray	Phosphorus Total	Free Iron (Fe_2O_3)	Manganese Total
				%	----------------	----------------	meq./100 gms. of soil	----------------	----------------	----------------	%	%	ppm	ppm	%	%
Ap	0-10	5.6	4.7	1.9	2.0	5.6	2.3	0.4	0.1	11.6	72	89	17.0	77.0	0.7	0.03
A21	10-18	5.0	3.9	1.1	2.0	2.9	1.5	0.3	0.1	7.6	63	71	3.8	65.0	1.1	0.03
A22cn	18-24	5.0	4.0	0.6	5.0	2.2	1.2	0.2	0.1	6.1	61	43	3.8	38.0	1.1	0.02
B1cn	24-30	5.5	4.3	0.6	8.3	4.5	2.9	0.4	0.7	13.9	61	51	4.7	26.0	1.7	0.03
B21t	30-38	6.6	5.5	0.5	9.5	7.7	4.5	0.4	1.3	18.4	76	59	3.8	24.0	3.2	0.03
B22t	38-53	7.3	6.3	0.4	5.5	10.7	6.2	0.5	2.1	25.1	78	78	3.8	30.0	3.2	0.02
B23t	53-64	7.2	6.3	0.4	3.5	11.5	7.0	0.6	2.1	23.8	89	86	11.3	36.0	4.3	0.03
B3	64-80	7.4	6.4	0.4	3.0	9.3	5.3	0.6	2.0	19.7	87	85	5.7	59.0	6.3	0.12
C	80-90+	7.4	6.4	0.3	3.0	9.1	5.7	0.6	2.0	20.1	87	85	3.8	59.0	3.7	0.07

TABLE IV

CHEMICAL PROPERTIES OF CHOTEAU-V

Horizon	Depth in Inches	pH 1:1	pH KCl	Organic Matter	Extractable Cations H	Extractable Cations Ca	Extractable Cations Mg	Extractable Cations K	Extractable Cations Na	Cation Exchange Capacity	Base Saturation (a)	Base Saturation (b)	Phosphorus Bray	Phosphorus Total	Free Iron (Fe_2O_3)	Manganese Total
				%	-----	-----	meq./100 gms.	of soil	-----	-----	%	%	ppm	ppm	%	%
A1	0-14	5.0	4.0	1.6	5.5	3.6	1.3	0.6	0.1	9.7	58	51	7.5	71.0	5.2	0.05
A21cn	14-20	5.1	3.8	1.3	7.5	2.2	1.3	0.3	0.1	7.7	51	34	3.8	62.0	6.9	0.05
A22cn	20-26	5.3	3.9	0.8	7.0	2.0	1.5	0.3	0.2	10.5	38	36	3.8	62.0	5.7	0.06
B21t	26-30	5.8	4.3	0.9	11.8	4.7	4.9	0.8	1.7	19.1	63	51	3.8	23.0	4.3	0.08
B22t	30-38	6.3	5.1	0.9	7.0	5.7	6.9	0.8	2.1	25.2	62	69	2.8	30.0	4.3	0.08
B3	38-60	7.4	6.0	0.4	3.8	6.6	7.2	0.3	3.2	25.1	69	82	2.8	42.0	6.2	0.15
R	60-65+	8.0	6.2	0.2	3.3	7.0	5.8	0.2	2.8	17.4	91	83	9.4	146.0	7.5	0.15

increase in pH with depth throughout the entire profile. Both soils are very acid in the surface 24 inches and then gradually become slightly acid to neutral or slightly basic.

The pH values of the KCl-soil mixtures range from 3.8 to 4.0 in the A horizons to 6.4 in the B horizons. These values follow the same general pattern as the water pH values and in most cases were at least one unit lower. This may indicate the presence of extractable aluminum.

Exchange acidity values range from 2 milliequivalents (meq.) in the A horizons of Choteau-L to 11.8 in the B21t of Choteau-V. The amounts are low in the surface, increase abruptly in the B2t horizons and then decrease in the lower B and C horizons. It would appear that with decreasing pH there should be an increasing amount of exchange acidity. However, these trends were not found. The increasing pH may be due to increasing amounts of extractable sodium and not related to the exchange acidity. The amounts of exchange acidity correlated with the amount of clay in the soil which could be a contributing factor to the high exchange acidity present.

<u>Extractable Cations, Cation Exchange Capacity, and Base Saturation.</u> Extractable cations are dominated by calcium and magnesium in Choteau-L. The values are lowest in the A2 horizons and highest in the B2 horizons. The B22t and B23t horizons were highest with 10.7 and 11.5 meq. of calcium and 6.2 and 7.1 meq. of magnesium respectively. The amounts of calcium and magnesium are lower in the surfaces than in most good Brunizem soil, but it is a common feature of many soils in the study area. This feature can be attributed to more leaching and eluviation. Potassium is very low throughout the profile and ranges from 0.2 to 0.6 meq. Sodium increases with increasing depth. Most of the sodium

appears to have been leached from the surface to the B2t horizons. Sodium values range from 0.1 meq. in the A horizon to 2.1 meq. in the B22t and B23t horizons.

Cation exchange values in Choteau-L range from 6.1 meq. in the A22cn horizon to 25.1 meq. in the B22t horizon. The cation exchange capacity (CEC) follows closely the distribution of clay in the profile, being lowest in the surface and highest in the B horizons and they appear to be related to the amount of clay. The CEC was high enough compared to the amount of clay present to be indicative of a montmorillonitic clay.

Percent base saturation ranged from 43% in the A22cn horizon to 89% in the Ap and B23t horizons respectively. Except for the decrease in the A2 horizons, there is a constant increase in base saturation with depth. The values were found to be higher by the Kjeldahl CEC method.

In Choteau-V, calcium and magnesium are lower than in Choteau-L. Calcium is still the dominant cation in the A horizons, but magnesium is equal to or greater than calcium in the B horizons. Calcium values range from 2.0 meq. in the A22cn horizon to 6.6 and 7.0 in the B3&C and R horizons respectively. Magnesium values range from 1.3 meq. in the A1 and A21cn horizon to 6.9 and 7.2 in the B22t and B3&C horizons. The difference is slight in the amounts of potassium and sodium in the two soils. Sodium is slightly higher in the lower B horizons, reaching 3.2 meq. in the B3&C horizon. Some sodium was detected in the parent rock, but the sodium increase may be due to leaching of sodium from the surface into the lower horizons.

The CEC are similar for the two soils and reflect similar clay mineralogy. The values are lowest in the A2 horizons and highest in the B2 horizons. The values of Choteau-V are slightly lower in the A1 horizon and slightly higher in the A2 horizons, with 7.7 and 10.5 meq., than in Choteau-L. The B2 horizons had values of 25 meq.

Base saturation values range from 38% in the A22cn horizon to 91% in the R horizon. The values obtained from the Kjeldahl CEC are higher than by the other method. The percentages are lower than those of Choteau-L.

Organic Matter. The amount of organic matter in the surface horizons ranges from 1.9% and 1.6% in the A horizons to a low of 0.4% in the B horizons. The amount of organic matter is lower in Choteau-V but remains higher for a greater depth than Choteau-L. The amount of organic matter is lower than for most Brunizem soils but, remains over 1% for 18-20 inches, giving the soils extra thick A1 horizons--an important characteristic.

Total and Available Phosphorus, Free Iron, Titanium and Manganese. Total phosphorus is moderately low and decreases with depth. Highest values of 77 ppm occur in the surfaces and may partly be due to fertilization. An increase occurs in the lowest depths which suggests the parent material to be higher in phosphorus. Even though there is measurable total phosphorus, there is very little available phosphorus. A high of 17 ppm occurs in the Ap horizon of Choteau-L. The amounts average less than 7 ppm for both soils.

The amount of free iron increases with depth. In Choteau-L, it ranges from 0.7% in the surface to 6.3% in the B3. In Choteau-V, no values of less than 4.3% were measured. The siltstone rock is the highest in free iron being 7.5%. Iron oxide was reported to be the binding agent in the rock (2). The iron contributes rusty brown colors and high values to the soil. More numerous and smaller concretions occur in Choteau-V and may account for the higher iron values since many of the larger concretions in Choteau-L were sieved out.

The total manganese in Choteau-L is 0.03% or less in each horizon except for an increase in the B3 and C horizons. Total manganese increased rather markedly with depth in Choteau 2. The values range from 0.05% in the A to 0.15% in the B3&C and R horizons of the soil. The presence of the higher amounts of manganese is apparent from Figure 9 and a violent reaction was brought about when treated with H_2O_2 to remove organic matter from the soil.

Titanium determinations were made but no detectable amounts were measured by the method used.

Chemical Properties of the Clay

Cation Exchange Capacity. The cation exchange capacity (CEC) of the clays are given in Table V. The CEC values of the total clays range from 32.1 to 31.5 meq./100g in the A22cn horizons. The highest value of 65 meq. occurred in the B22t and B23t horizons of Choteau-L. The fine clay of Choteau-L has the highest exchange capacity with 90 meq. In Choteau-V, the values range from about 70 meq. to 84 meq. and increases with depth. There is a considerable reduction in the values in Choteau-V. Part of the lower values may be attributed to incomplete separation of the clays but could be due to differences in clay mineralogy. The coarse clays possess much lower CEC. The values range

TABLE V

THE CATION EXCHANGE CAPACITY AND TOTAL K_2O CONTENT OF CLAY FRACTIONS AND PERCENTAGES OF FINE AND COARSE CLAY OF SELECTED HORIZONS FROM THE CHOTEAU SOILS

Horizon	CEC	Meq./100gms		K_2O Content			% Clay	% Clay	Fine Clay / Coarse Clay
	tc	cc	fc	tc	cc	fc	2-0.2μ	<0.2μ	
				Choteau-L					
Ap	43.7	37.3	91.9	1.4	1.3	1.5	8.9	7.0	0.79
A22cn	37.4	32.1	89.9	1.8	2.0	1.6	9.2	5.0	0.54
B1cn	40.2	36.6	88.9	2.2	3.0	1.6	9.0	14.3	1.59
B22t	64.9	39.2	89.3	1.8	3.0	1.6	11.8	28.0	2.37
B23	65.8	--	--	1.9	--	--	--	--	--
C	55.7	48.6	87.3	1.9	3.1	1.7	11.5	25.9	2.25
				Choteau-V					
A1	44.3	36.6	69.8	2.3	2.7	1.6	7.1	2.8	0.40
A22cn	31.5	--	--	2.3	--	--	--	--	--
B22t	54.8	43.4	80.6	2.2	2.7	1.8	22.9	18.2	0.79
B3&C	45.1	--	--	3.2	--	--	--	--	--
R	35.4	32.7	84.3	4.4	4.1	4.7	13.2	2.1	0.16

from 32 to 48 meq. in Choteau-L, and 32 to 43 meq. in Choteau-V. Both soils have rather uniform values with depth indicating similar clays.

Non-Exchangeable Potassium. Non-exchangeable potassium has been thought to be a good indication of the amount of illite or micaceous clay. Mehra and Jackson (38) have examined many samples of illite material and established a 10% K_2O value to represent 100% illite which differs from the figure established earlier by Grim, Bray and Bradley (17).

The percentages of non-exchangeable potassium of the clay fractions from selected horizons of the Choteau profiles are presented in Table V. Contents of K_2O in the total clay range from 1.4%-2.2% in Choteau-L to 2.2%-3.2% in Choteau-V. The percentages of K_2O in the coarse clay range from 1.3% in the Ap horizon to 3.1% in the C horizon in Choteau-L. As compared to values of 2.6% in the A1 and B22t horizons and of 4.1% in the R horizon for the Choteau-V, the R horizon also has high K_2O values of 4.7% and 4.4% in the fine and total clay respectively. These high values are due to macaceous materials present in the clay. Flakey material resembling micas was observed visually in rocks in the field and was also observed in the fine and very fine sand fraction. By microscopic examination it was identified as degraded micas, mostly muscovite. Bell (2) has reported similar occurrences. Micas could account for the higher values in these horizons.

From the chemical data, the types of clay in the two soils appear to be similar. The fine clays have high CEC and low K_2O contents and suggest a montmorillonitic type of clay. In Choteau-V, there is an increase in the percentage of clays with lower CEC. Both soils have less than 20% illite. The coarse clays have much lower CEC and higher

K_2O contents. These values suggest a mixed clay mineralogy with higher (20%-30%) illite contents. Both soils do have high enough CEC values to indicate low percentages of kaolinitic clay. Because of the findings, the clay mineralogy of both could be classified as mixed with Choteau-L being more montmorillonitic and Choteau-V being more illitic.

Jarvis (28) worked on the Taloka series and obtained results similar to these. He found an abundance of montmorillonite (50%-70%), 10%-30% illite, and very small amounts of kaolinite. Fanning (11) found montmorillonite to be the dominant clay mineral of the fine clay in the Dennis series and illite and kaolinite in the coarse clay. This also follows closely the general statement by Bray (4) on clay formation.

Feldspar Mineral Determination

Results of the feldspar mineral determinations are given in Table VI and in Tables VIII and IX of the Appendix.

Na-feldspars dominate the feldspar minerals in both profiles. It is the most abundant mineral in the fine sand, very fine sand and coarse silt in every horizon. K-feldspars were found to be less abundant than the Na variety. Ca-feldspars were not present in either profile.

The percent of Na and K-feldspars increases rather uniformly with decreasing particle size but, in the coarse silt the percentage of feldspars decreases slightly with depth. The total percentage of Na and K-feldspars in the soil of both profiles is rather uniform with depth. In both soils, with increases or decreases in one feldspar mineral there is a corresponding increase or decrease in the other feldspar

TABLE VI

PERCENTAGE OF FELDSPARS AND QUARTZ IN THE RESIDUE, AND THE QUARTZ-FELDSPAR RATIO OF THE CHOTEAU SOILS

Horizon	Depth in Inches	Total K_2O	Total Na_2O	Total CaO	Total Feld.	Quartz*	$\frac{\text{Quartz}}{\text{Feldspar}}$
			Choteau-L				
AP	0-10	4.0	6.0	0.0	9.9	90.1	9.1
A21	10-18	3.8	5.9	0.0	9.7	90.3	9.3
A22cn	18-24	3.8	5.8	0.0	9.5	90.5	9.5
B1cn	24-30	3.9	5.9	0.0	9.9	90.2	9.2
B21t	30-38	4.0	6.2	0.0	10.1	89.8	8.8
B22t	38-53	3.5	5.5	0.0	8.9	91.0	10.2
B23t	53-64	3.6	5.8	0.0	9.4	90.6	9.6
B3	64-80	3.1	4.8	0.0	7.9	92.1	11.6
C	80-90+	3.4	5.9	0.0	9.3	90.7	9.7
			Choteau-V				
A1	0-14	5.3	7.5	0.0	12.8	87.2	6.8
A21cn	14-20	5.4	7.9	0.0	13.3	86.7	6.5
A22cn	20-26	5.6	6.9	0.0	12.5	87.4	7.0
B21t	26-30	4.4	7.5	0.0	11.9	88.1	7.4
B22t	30-38	4.5	7.3	0.0	11.8	88.2	7.5
B3&C	38-60	4.8	8.3	0.0	13.1	86.9	6.7
R	60-65+	6.9	10.7	0.0	17.6	82.4	4.7

*Quartz in residue, assuming all resistant minerals remaining were quartz and feldspars.

mineral. The percentage of total feldspars range from 9% in Choteau-L to 17.6% in Choteau-V.

Total quartz percentages range from 82.4% in the R horizon of Choteau-V to 92.1% in Choteau-L. In Choteau-L, the amounts are higher in the B and C horizons. In Choteau-V, values are highest in the surface and decrease with depth. Choteau-V has about 30% more feldspars in the profile and has a much lower quartz-feldspar ratio than does Choteau-L.

From the feldspar data, it would appear that both soils are low to very low in feldspar minerals. Assuming both soils have approximately the same parent material, it could be concluded that Choteau-L was more weathered than Choteau-V.

Uniformity of Parent Material

The particle size distribution, abrupt increases in exchange acidity and a few minor findings indicate that a discontinuity may exist at the top of the B21t horizon. These features may be attributed as easily to soil forming processes and soil maturity.

A recalculation of the particle size distribution data on a clay free basis was made and is reported in Table VII. From this data, it is apparent that there is a very constant percentage of fine sand, very fine sand, and silt with depth in the profile. The unconformity in the lower two horizons of the soil profile are due to incomplete dispersion of rock fragments and have contributed to the larger percentages of sands and less silt.

TABLE VII

PARTICLE-SIZE DISTRIBUTION OF THE FINE SAND, VERY FINE SAND, AND COARSE AND FINE SILT ON A CLAY-FREE BASIS

Horizon	Depth in Inches	Size in Millimeters .25-.1	.1-.05	.05-.02	.02-.002	Total Silt
		Choteau-L				
Ap	0-10	5.1	15.9	43.9	34.4	78.3
A21	10-18	5.5	16.9	43.3	33.3	76.6
A22cn	18-24	5.6	17.7	44.9	30.6	75.5
B1cn	24-30	6.3	17.3	40.4	34.4	74.8
B21t	30-38	6.2	15.2	36.9	39.4	76.3
B22t	38-53	6.0	14.0	34.5	42.8	77.3
B23t	53-64	7.4	16.1	34.2	39.7	73.9
B3	64-80	11.5	20.8	30.8	26.7	57.5
C	80-90+	12.3	23.3	31.7	25.7	56.4
		Choteau-V				
A1	0-14	1.7	12.6	49.8	24.4	74.2
A21cn	14-20	1.4	9.8	44.9	29.3	74.2
A22cn	20-26	1.7	9.8	40.0	31.5	71.5
B21t	26-30	2.4	9.6	37.4	40.1	77.5
B22t	30-38	2.6	10.0	32.9	44.3	77.2
B3&C	38-60	3.8	8.8	24.4	33.2	57.6
R	60-65+	10.5	12.3	27.9	41.7	69.6

A uniform distribution of feldspar minerals occurs in the particle sizes sampled in both soils. There is no significant difference in the total percent of Na or K-feldspars in any of the horizons.

We can therefore conclude that both the size and composition of the mineral grains in the present profile are uniform and that the parent material at time zero was also uniform.

Because of the high silt contents and the presence of siltstone and silty sandstone, it is concluded that these soils developed from siltstone, with lenses of sandstone and shale.

Comparisons with Similar Soils

Differentiating criteria for the Choteau series are (1) a mollic epipedon, (2) a thick A2 horizon, (3) a gradual boundary between the A2 and the underlying B horizon, and (4) a maximum clay content of 35%.

Unpublished data (12) from Choteau soils in Wagoner County were compared with data obtained in this study. Percentages of sand and silt, pH and extractable cations showed only slight differences. Three criteria, percent clay, percent organic matter and base saturation were selected for comparisons and are shown in Figures 3, 4, and 5.

Choteau-L showed a significant decrease in clay content in the A2 horizon as compared to a small but increasing clay percentage to the top of the B horizons in the other three soils. Choteau-V showed an abrupt increase in clay content from 16% to 42% in four inches. Choteau-L and Choteau-3 have 40% clay contents, but the increases were gradual. Choteau-4 shows a gradual increase in clay but was the only one within the 35% clay concept.

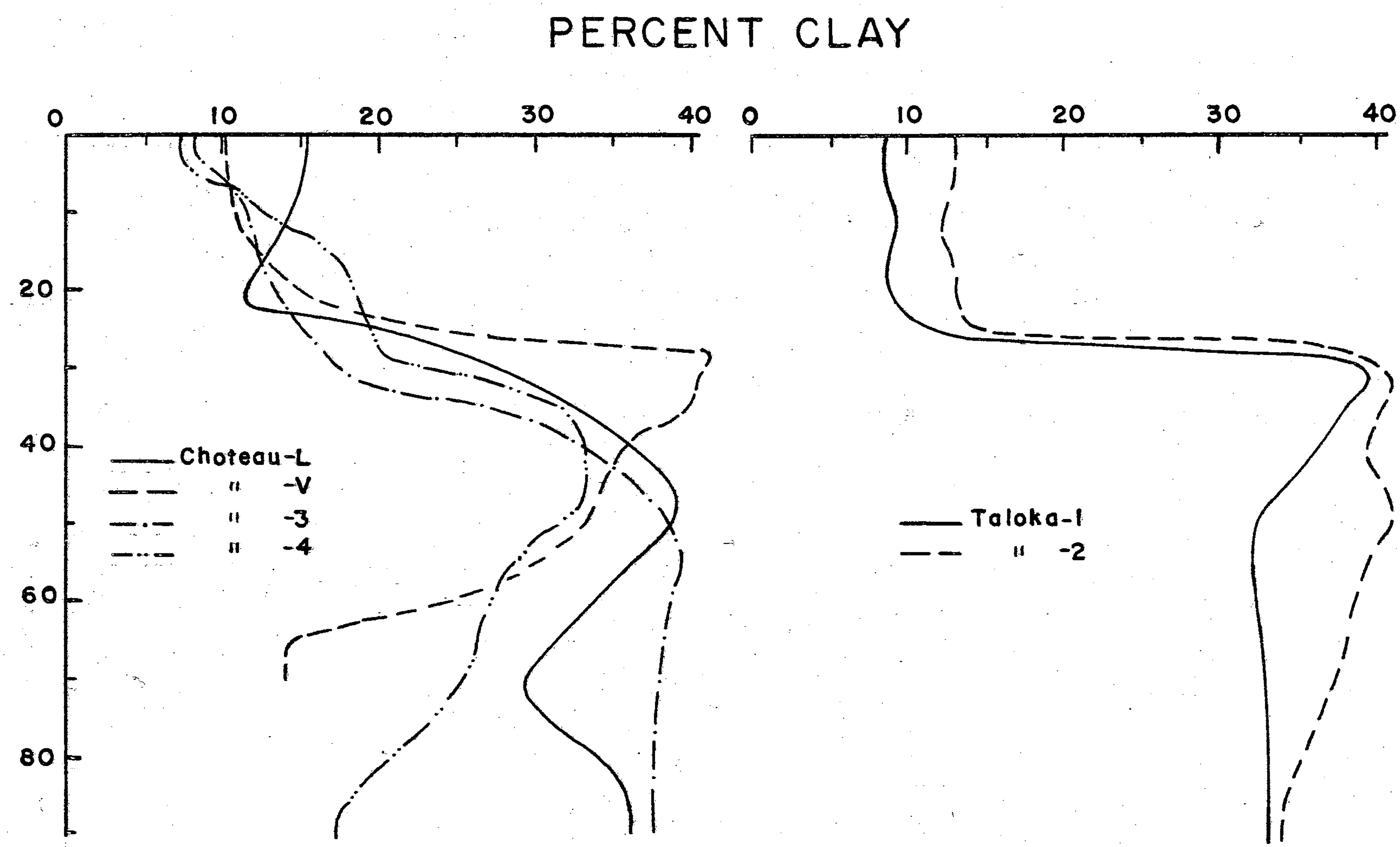

Figure 3. Distribution of Clay With Depth in Choteau and Taloka Soils

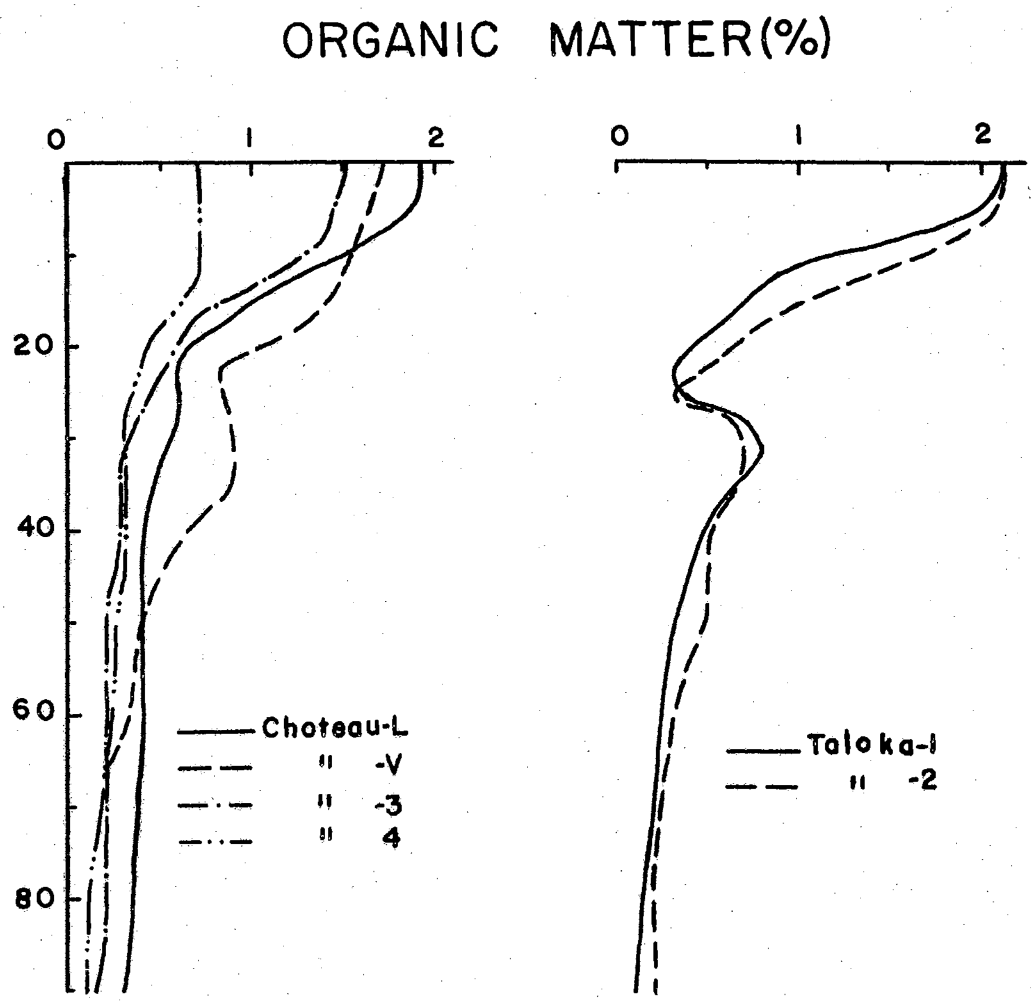

Figure 4. Distribution of Organic Matter With Depth in Choteau and Taloka Soils

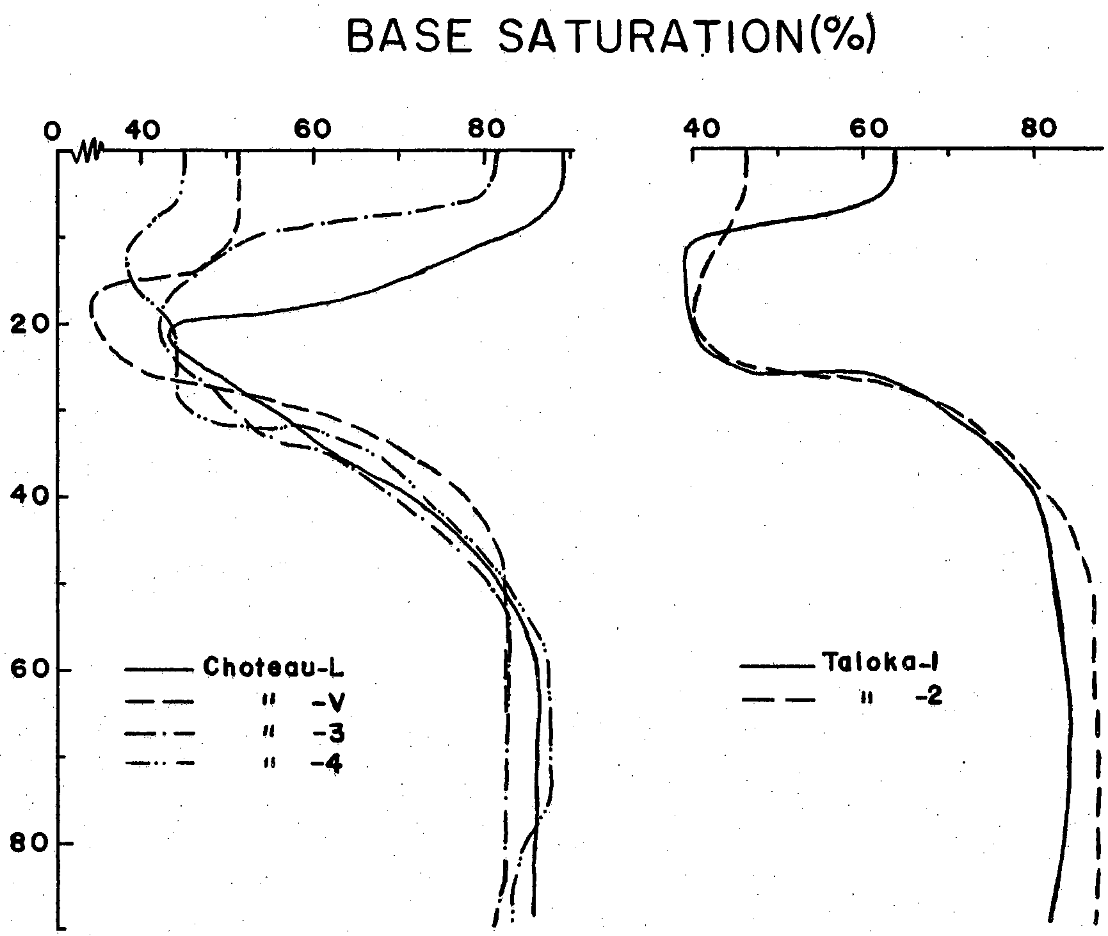

Figure 5. Distribution of Base Saturation With Depth in Choteau and Taloka Soils

Percent organic matter is plotted with depth in Figure 4. All four soils show a rapid decrease in percent organic matter below 10 inches. Except for Choteau-4, the values remain above 1% for from 13-20 inches. Choteau-4 has only 0.7% organic matter even in the A1 and would not qualify for a mollic epipedon.

The percent base saturation is plotted with depth in Figure 5. All four soils have high percentages in the A horizons, decreases abruptly in the A2 horizon and then gradually increases to a depth of 50 inches below which the percentages are constant. Below 35 inches, the curves are similar, however, the surfaces are different. Two soils, Choteau-L and Choteau-3, have percent base saturation above 80% in the A horizon and Choteau-V has a value of 51%. All three have base saturations above 50% which is diagnostic for mollic epipedon. Choteau-4 has base saturation values of 45% in the surface which is too low to qualify for mollic epipedon.

From the data, it can be concluded that all of the pedons had clay contents that ranged from 34.4% to 41.7% maxima and only one soil had clay contents below 35%. Base saturation was the most variable characteristic ranging from 45% up to 89%. Only Choteau-4 does not qualify as having a mollic epipedon an important criteria of both series and soil order classification, even though it has the ideal clay distribution curve for the series concept. Choteau-V probably has too sharp an increase in clay content to be included in the Choteau series.

A comparison was also made between the Choteau soils and two Taloka soils studied by Brengle (7). The same criteria were used for comparison and the data is plotted with depth in Figures 3, 4, and 5.

The percent clay is plotted with depth in Figure 3. Both soils have very similar clay distribution curves. The percent clay is constant through 24 inches and then very abruptly increases to 40% in about 3 inches. Choteau-V is the only other soil that has a similar curve. The other profiles have a much more gradual increase. However, the maximum clay contents are similar to those of the Taloka soils.

The percent organic matter is plotted in Figure 4. The curves show very similar shapes to those of the Choteau soils except for an increase in organic matter in the B21t horizon. Choteau-V is more similar to the Taloka than the Choteau soils.

The percent base saturation is plotted in Figure 5. They are very similar to the curves of the Choteau soils. The Taloka soils show a broader area of decrease in the A2 horizon, but the increases in the B horizons are very similar. One soil is below 50% base saturation and one is above 50% base saturation.

In conclusion, Taloka-2 would not qualify for mollic epipedon on the basis of low base saturation. However they may be valid as the same series since all other criteria are similar. Choteau-V pedons could be classified better as a Taloka.

From comparison of all the data, it appears that the gradual boundary vs. the abrupt boundary is an important criteria for the field man to use in separating Taloka pedons from Choteau pedons. The maximum clay content appears to be a poor criteria since both series overlap between 35% and 40% clay. It would be possible to predict that a large percentage of both series will have pedons with clay contents in this range.

Based on these studies, the Choteau series as presently defined is only a concept and does not exist as a real mappable soil type. Until more studies to obtain more definite differences between the Choteau and Taloka soils are initiated, soil types now involving Choteau and Taloka should be correlated as Taloka-Choteau silt loam, complexes of two similar kinds of pedons.

Soil Genesis

The presence of thick silty A1 and A2 horizons makes it difficult to interpret soil genesis. The exact manner in which the soil was developed will probably never be known. The data seems to indicate that the thick silty surface is not a loess mantle, or if it is, it is local in origin. The distribution of sands and silts are very uniform with depth. The chemical and mineralogical data support little or no evidence of discontinuity. Rutledge, Chapman and Horn (8, 43) have found similar indications in Arkansas soils. The thick A2 horizons could have formed under a forest environment which later changed to grasses.

The parent material is believed to be a weakly cemented silicious siltstone of low mineral status, with lenses of sandy shale and clays. Under a high rainfall the material weathers easily because of its highly permeable and porous nature. The siltstone was leached of cations and clay under a forest environment. Weathering was rapid and because there were few clay forming minerals, a soil developed with a deep, light colored surface with a cambic B horizon forming deep in the profile. Then, a vegetative changeover to grass occurred. The grasses added organic matter and color to the upper part of this light colored surface, cations were brought to the surface and exchange acidity was reduced. With time, this has resulted in thicker A1 horizons and the A2 horizon is part of the original light colored surface.

Soil Classification by 7th Approximation

Choteau-L

Order. . . . . .Mollisol

Suborder. . . . . Albolls

Great Group. . . . . .Argialbolls

Subgroup. . . . . Aquollic Argialbolls

Family . . . . .Fine silty, mixed, thermic

Series. . . . . Choteau

7th Approximation name: fine silty, mixed, thermic

Aquollic Argialbolls

The soil should not have 2 or less chroma mottles to be Choteau, but all other criteria fit the series. The B2t horizons averages 35% clay.

Choteau-V

Order. . . . . .Alfisol

Suborder. . . . . Udalfs

Great Group. . . . . .Normudalfs

Subgroup. . . . . Albaqualfic Normudalfs

Family . . . . .Fine, mixed, thermic

Series. . . . . Not Choteau

7th Approximation name: fine, mixed, thermic

Albaqualfic Normudalfs

The surface horizon is too light in color for the mollic epipedon.

The argillic horizon has 2 or less chromas and an abrupt textural change with over 35% clay.

CHAPTER VI

SUMMARY AND CONCLUSION

Slight morphological differences occur between Choteau-L found on the footslopes and Choteau-V on the flats. The differences occur mostly in the B horizons. The B2t horizon of Choteau-V is thinner being only half as thick as the B2t horizon of Choteau-L. A more abrupt A2 to B2 boundary and more red and yellow colored B horizon underlying siltstone are features of the Choteau-V that differ.

The physical properties of the two soils are very similar. Both soils are of the silt loam type and the percentages of sand, silt and clay are much the same for any particular horizon. Choteau-L has lower percentages of coarse sands and a slightly less abrupt increase in clay content than did Choteau-V. The Choteau-L pedon has silty clay loam B2t horizons whereas Choteau-V B2t horizons are silty clays.

The pH, organic matter, cation exchange capacity, phosphorus (available and total), and extractable cations, except calcium and magnesium are very similar in both soils. In Choteau-V, however, magnesium values are higher than calcium in the lower part of the profile. There are higher percentages of free iron and total manganese and lower base saturations than in Choteau-L.

The clay mineralogy appears to be of mixed clays with the coarse clay being dominantly illitic and the fine clay being montmorillonitic.

Choteau-V has higher percentages of coarse clay, more total K_2O and lower CEC which suggest a more illitic soil. Choteau-L has higher percentages of fine clay, higher CEC and lower total K_2O content suggestive of a more montmorillonitic soil.

The sand and silt mineralogy indicates high percentages of quartz; sodium is the dominant feldspar mineral with smaller amounts of K-feldspars and no Ca-feldspars determined. There is a uniform distribution of feldspars in the profile. The percentage of feldspars increases with decreasing particle size.

The very curved nature of the clay distribution, CEC and chemical analysis plotted with depth point out changes in the profile, especially the pronounced minimum and maximum values in the A2 and B2t horizons respectively. It is evident that both soils have undergone strong leaching and have produced soils with maximum profile development. Cations and clay have been removed from the surfaces, especially the A2 horizon, but additions of organic matter have caused dark colored A1 horizons. The cations and clay have translocated in the B2t horizons.

From the particle-size distribution, chemical and mineralogical data, it was concluded that the soil parent material was essentially of uniform texture and mineralogy at time zero and was probably weakly cemented siltstone. Not only was the material uniform within the sample pedon but it was uniform between the two pedons with only slight differences. If the soil is partially a loess mantle, it is locally derived and has been mixed and weathered to the extent that its significance in classification is unimportant.

From comparison of all the data, it appears that the gradual vs. abrupt B2t boundary is an important criteria for differentiating between the Choteau and Taloka pedons. The maximum clay content appears to be a poor criteria since both series overlap between 35% and 40% clay. It appears that Choteau may only be a concept and not a real mappable soil type and should be correlated as Taloka-Choteau silt loam complexes.

Difficulty was encountered in establishing a logical classification for the Choteau series based on the limited number of pedons sampled. The sampled pedons and the other Choteau pedons mentioned seem to intergrade between the Mollisol and Alfisol orders. Pedons similar to Choteau-L have been classified as fine silty, mixed, thermic family of Aquollic Argialbolls while pedons similar to Choteau-V have been classified as fine, mixed, thermic Albaqualfic Normudalfs and are more like Taloka soils.

More of these similar studies are needed in relation to land forms and soil characteristics before Choteau-L pedons can properly be classified and accurately mapped in Oklahoma.

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APPENDIX

TABLE VIII

THE PERCENTAGE OF Na, K, AND Ca FELDSPARS IN THE FINE SAND, VERY FINE SAND, AND COARSE SILT FRACTIONS OF THE CHOTEAU SOILS

Horizon	Depth in Inches	K_2O Feldspar			Na_2O Feldspar			CaO Feldspars
		fs	vfs	csi	fs	vfs	csi	
				Choteau-L				
AP	0-10	1.1	2.0	5.0	3.3	3.5	7.2	0.0
A21	10-18	0.9	1.4	5.1	2.6	3.0	7.5	0.0
A22cn	18-24	0.6	1.4	5.1	1.3	3.4	7.3	0.0
B1cn	24-30	0.9	1.5	5.4	2.5	3.1	7.7	0.0
B21t	30-38	2.9	1.4	5.2	4.7	3.4	7.6	0.0
B22t	38-53	0.7	1.2	4.9	1.4	3.4	7.0	0.0
B23t	53-64	0.7	1.2	5.4	1.3	3.6	7.8	0.0
B3	64-80	1.0	2.3	4.4	1.7	4.4	6.3	0.0
C	80-90+	2.0	2.5	4.6	5.7	4.9	6.7	tr.
				Choteau-V				
A1	0-14	1.0	3.0	6.0	1.5	4.0	8.6	0.0
A21cn	14-20	3.6	3.1	5.9	3.5	3.8	9.0	0.0
A22cn	20-26	3.1	3.3	6.3	3.6	7.2	10.5	0.0
B21t	26-30	6.3	3.3	4.6	9.0	8.3	11.2	0.0
B22t	30-38	4.1	3.6	4.8	6.4	8.7	6.9	0.0
B3&C	38-60	4.2	4.3	5.0	6.4	11.9	7.2	tr.
R	60-65+	2.5	9.0	7.6	2.9	17.0	10.9	tr.

TABLE IX

THE PERCENTAGE OF Na, K, AND Ca FELDSPARS IN THE CHOTEAU SOILS CONTRIBUTED BY THE FINE SAND, VERY FINE SAND, AND COARSE SILT FRACTIONS

Horizon	Depth in Inches	K_2O Feldspar fs	K_2O Feldspar vfs	K_2O Feldspar csi	Na_2O Feldspar fs	Na_2O Feldspar vfs	Na_2O Feldspar csi	CaO Feldspars
				Choteau-L				
AP	0-10	0.1	0.5	3.4	0.3	0.9	4.9	0.0
A21	10-18	0.1	0.4	3.4	0.2	0.8	4.9	0.0
A22cn	18-24	0.1	0.4	3.4	0.1	0.9	4.8	0.0
B1cn	24-30	0.1	0.4	3.4	0.2	0.8	4.9	0.0
B21t	30-38	0.3	0.4	3.3	0.5	0.9	4.8	0.0
B22t	38-53	0.1	0.3	3.1	0.2	0.9	4.4	0.0
B23t	53-64	0.1	0.3	3.2	0.2	1.0	4.6	0.0
B3	64-80	0.2	0.8	2.2	0.3	1.5	3.1	0.0
C	80-90+	0.4	0.9	2.2	1.8	1.7	3.2	tr.
				Choteau-V				
A1	0-14	0.1	0.6	4.7	0.1	0.8	6.7	0.0
A21cn	14-20	0.1	0.5	4.7	0.1	0.7	7.2	0.0
A22cn	20-26	0.1	0.6	4.9	0.1	1.4	5.4	0.0
B21t	26-30	0.3	0.6	3.5	0.4	1.6	5.5	0.0
B22t	30-38	0.2	0.8	3.5	0.4	1.9	5.0	0.0
B3&C	38-60	0.4	1.0	3.3	0.7	2.8	4.8	tr.
R	60-65+	0.5	2.2	4.2	0.6	4.1	6.0	tr.

Figure 6. Pipestems of pale brown very fine sand and silt described in the B22t horizon of Choteau-L. The ped is approximately 2 1/2 inches across.

Figure 7. The very porous massive structure of the A2 horizon described in Choteau-L. Notice the circular worm casts in the center right and the abundance of rounded excrete from the worms. Concretions are not apparent from this picture because of coatings of soil material from the horizon. Clod is approximately 6 inches across.

Figure 8. Photomicrograph thin section from the material in the above figure. It shows large numerous concretions embedded in a matrix of silt sized particles with no apparent orientated clays.

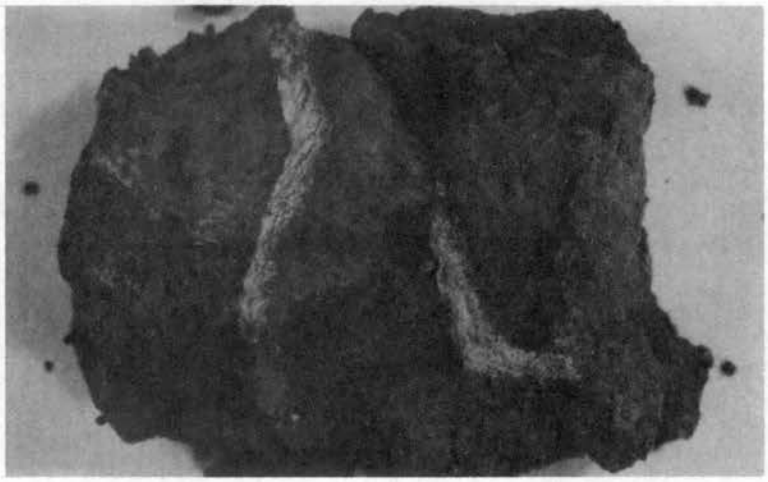

Figure 6

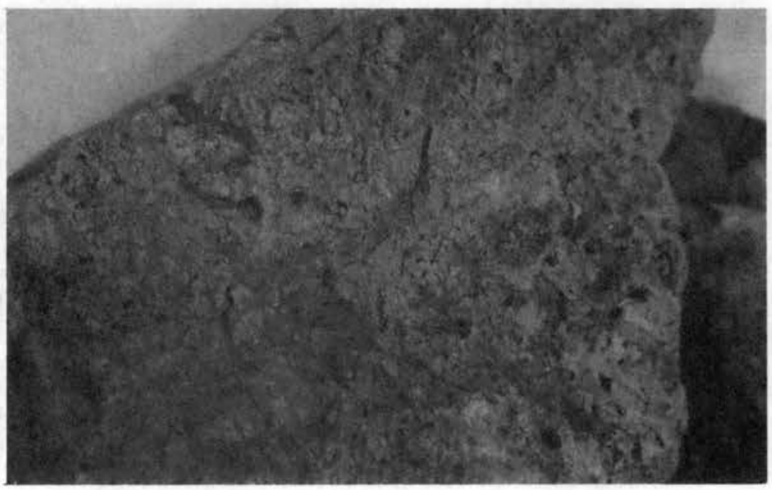

Figure 7

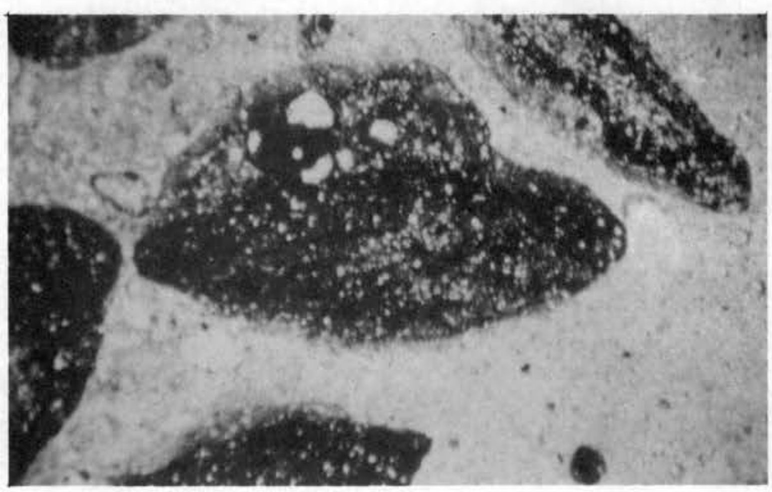

Figure 8

Figure 9. Irregular void with thick mangan cutan; also a compound argillian and mangan cutan along channel wall. Clay is orientated more on the upper wall but manganese is concentrated more along the lower wall. Vert. section, crossed polarized, 80X.

Figure 10. A concentric, thick, strongly orientated argillian along the walls of a filled void. It is dissected by a channel with weak argillian and mangan cutans. Note other orientated clay in the soil matrix. Vert. section, crossed polarized, 80X.

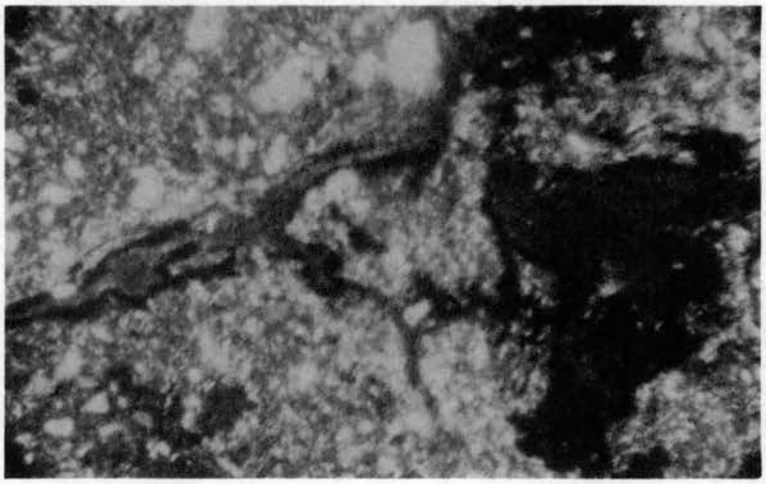

Figure 9

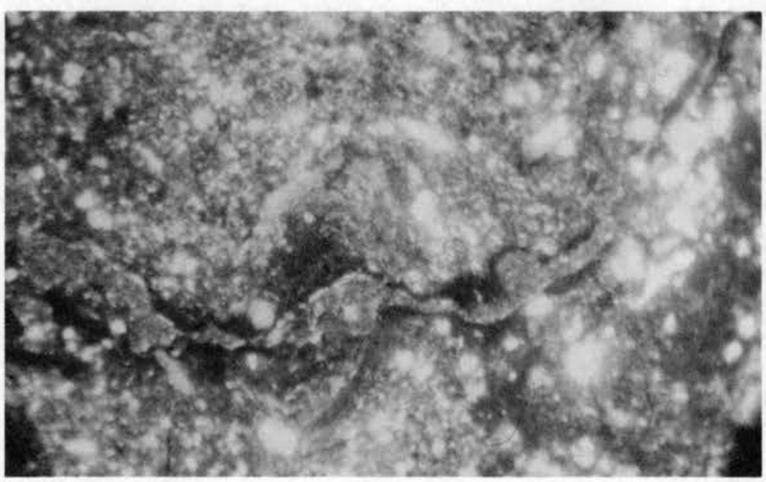

Figure 10

VITA

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